

Quantum State Analyser & Secure Pipeline

High-Performance Cloud Service for Quantum Density Matrices & Choi Operators (v1.0)

1. System Overview & Architecture

The Quantum Engine API is engineered for high-performance processing of complex state matrices and continuous variable optical fields. Hosted securely on Google Cloud Run, the system utilizes a robust master router (core_engine.py) that separates discrete quantum operators from continuous variable wavefronts. Density matrices are rigorously normalized to ensure $\text{Tr}(\rho)=1$ allowing precise calculation of purity scores, phase dispersion, Von Neumann entropy, Fidelity, Concurrence, and automated Choi matrix channel detection.

2. Backend Modules & Tier Limits

- **app.py:** Flask production container featuring automated IP-based rate limiting (30 free requests per day per visitor IP), secure payload validation, and API key authorization headers.
- **core_engine.py:** Mathematical core containing purity evaluation, phase variance calibration, entropy, fidelity, concurrence, and channel status flags.
- **Tier Access:** Free tier includes 30 requests/day per IP (up to 5000x5000 matrices). Lab/Enterprise partners receive unlimited access via the Authorization: Bearer <LAB_API_KEY> header.

3. Supported Quantum Metrics

Metric Name	Mathematical Basis / Purpose	Application Target
purity	$\text{Tr}(\rho^2)$	Quantifies mixedness vs purity
von_neumann_entropy	$S(\rho) = -\text{Tr}(\rho \log \rho)$	Information entropy / mixedness
fidelity_to_maximally_mixed	$F(\rho, \sigma)$	Coherence checking against baseline
concurrence	Spin-flip entanglement metric	2-Qubit entanglement quantification
is_choi_matrix	CPTP channel verification	Process tomography / Choi channels

4. Performance Benchmark Results

Dimension / Mode	Pipeline Target	Purity Score	Status Flag	Exec Time
4x4	Cirq Circuit ($\epsilon=0.05$)	92.40%	MAXIMAL ENTANGLEMENT	0.14 s
200x200	Discrete Operator	88.15%	MAXIMAL ENTANGLEMENT	0.28 s
1000x1000	High-Dim Matrix	76.40%	DEGRADED MIXED STATE	0.95 s
2000x2000	High-Dim Benchmark	64.10%	DEGRADED MIXED STATE	2.12 s
5000x5000	Max Limit Matrix	52.80%	DEGRADED MIXED STATE	6.45 s
Continuous	Optical Wavefront	81.20%	COHERENT BEAM	0.32 s

5. Quick Integration Code Snippet

```
import requests
API_URL = 'https://quantum-engine-api-730441989527.us-central1.run.app/analyze'
headers = {'Content-Type': 'application/json', 'Authorization': 'Bearer YOUR_LAB_KEY'}
payload = {'real_matrix': [[0.5, 0, 0, 0.5], [0, 0, 0, 0], [0, 0, 0, 0], [0.5, 0, 0, 0.5]], 'imag_matrix': [[0]*4 f
or _ in range(4)]}]
response = requests.post(API_URL, json=payload, headers=headers)
print(response.json())
```

6. Support & Commercial Inquiries

Public trial requests are rate-limited to 30 requests per day per network IP. For custom enterprise allocations, dedicated compute tiers, or API key integration, contact the development team.

Live Demo Portal: <https://quantum-engine-api-730441989527.us-central1.run.app/>

Contact: rohithdawan28@gmail.com